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ABSTRACT

The relationship between automatization ability (the tendency for repetitive routine aspects of behavior to become so overlearned that a minimum of conscious effort and attention is necessary for rapid efficient execution), as measured by the Rapid Automatic Naming (RAN) Test, and proficiency in arithmetic basic fact computation was investigated with 120 learning disabled and 120 nondisabled children ages 8 to 13 years. Sixty Ss in each group were designated as either younger or older. Significant correlations were obtained between RAN performance and arithmetic proficiency for both the learning disabled and nondisabled groups. In addition, learning disabled Ss were found to be less proficient in simple computation and slower on RAN than their nondisabled peers at both younger and older age levels. (Author/SB)

RESEARCH INSTITUTE FOR THE STUDY OF LEARNING DISABILITIES
Teachers College, Columbia University

AUTOMATIZATION AND BASIC FACT PERFORMANCE OF NORMAL AND LEARNING DISABLED CHILDREN

Katherine Garnett and Jeannette E. Fleischner

Technical Report #10

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Abstract

The relationship between automatization ability, as measured by the Rapid Automatic Naming Test, and proficiency in arithmetic basic fact computation was investigated in this study. Subjects were 120 learning disabled and 120 nondisabled children between 8 and 13 years of age; 60 subjects in each group were designated as either younger or older. Significant correlations were obtained between RAN performance and arithmetic proficiency for both the learning disabled and nondisabled groups. In addition, learning disabled subjects were found to be less proficient in simple computation and slower on RAN than their nondisabled peers at both younger and older age levels.

Automatization and Basic Fact Performance of Normal and Learning Disabled Children

Learning disabled children have been shown to be less proficient than their nondisabled peers in computing basic arithmetic facts (Fleischner, Garnett & Shepherd, 1979). It is not clear exactly what psychological factors underlie this difficulty. Although many factors appear to combine to affect overall arithmetic achievement (i.e., general intelligence, spatial orientation, visual-perception, verbal abilities, and problem solving ability), to date there has been no investigation of what factors may be most significant in basic number fact proficiency in particular.

Basic number facts comprise all single-digit addition, subtraction, multiplication, and division problems (e.g., $3 + 4$; $7 - 3$; $7 - 4$; 5×7; $35 \div 5$; $35 \div 7$). Speed and accuracy in answering these single-digit problems is considered to be important because they are components of more complex arithmetic computations.

Taxonomies of arithmetic computational difficulties list basic fact errors as an important and common type of error (Buswell & John, 1926; Brueckner & Bond, 1955; Cohn, 1968; Cox, 1975; Frank, 1979). Clinical reports and standard texts assert that mastery of basic facts represents an area of particular difficulty for learning disabled children, and Fleischner, Garnett & Shepherd (1979) found LD children to be significantly less proficient than their nondisabled peers in computing basic fact problems on timed trials.

Brownell (1935) identified a developmental progression in basic fact computation, which ranges from simple counting strategies such as those described by Gelman and Gallistel (1978) to habituation of response. Habituation was characterized by Brownell (1935) as the stage marked by swiftness of response, and the absence of identifiable intermediary thought processes. In other words, these facts are accessible for automatic retrieval. To the layman, this stage represents the "memorization" of basic facts which is an

important goal of the early years of arithmetic instruction.

Automatization is considered to be an important psychological process in the development of task proficiency. Automatization has been defined as "the tendency for repetitive routine aspects of behavior to become so overlearned that a minimum of conscious effort and attention is necessary for rapid efficient execution" (Broverman, Clarkson, Klaiber, & Vogel, 1978, p. 2). Differences in automatization ability are considered to reflect differences in cognitive style, which, in turn, influence ability to benefit from extended practice. Automatization is not significantly involved in the initial learning of novel and complex tasks, but, rather, influences the rate at which performance becomes efficient after accuracy has been achieved.

One index of the proclivity to automatize is speed of naming repeated instances of highly familiar stimuli. Typically, categories such as primary colors, letters, numbers, and pictures of common objects have constituted the stimulus classes used in measuring rapid automatic naming (Broverman, 1960; Blumenthal, 1977; Denckla & Rudel, 1976; Drake & Schnall, 1966; Rutherford & Telser, 1967).

Studies of repetitive naming performance in learning disabled children have found that they perform more slowly than their nondisabled peers (Blumenthal, 1977; Denckla & Rudel, 1976; Drake & Schnall, 1966; Eakin & Douglas, 1971). A conclusion of some of these investigators has been that this slow performance reflects diminished proclivity to automatize information. Others have held that specific language difficulty is reflected in this poor performance.

The present study postulated that acquiring proficiency in basic arithmetic facts relies to a considerable extent on the process of automatization. Therefore, the purpose of the study was to explore the relationship between a measure of automatization (Rapid Automatic Naming Test, Denckla &

Rudel, 1976) and proficiency in the computation of basic number facts. The primary focus was the extent to which speed/accuracy on basic addition, subtraction and multiplication facts is related to rapid automatic naming speed in learning disabled and nondisabled children.

Method

Subjects

Subjects (Ss) for this study were 120 (101 boys, 19 girls) learning disabled (LD) and 120 (83 boys, 37 girls) nondisabled children. Ss ranged in age from 96 to 158 months. In each group, 60 Ss who were 124 months of age or less were designated as younger and 60 whose age exceeded 124 months were designated as older.

Normal Ss were enrolled in ten different classrooms of grades 3 to 6 in two schools of a rural school district in Maine. Children identified as being handicapped (LD, mentally retarded, emotionally handicapped, or sensory impaired) were excluded from this sample. While IQ data were not available for these Ss, average IQ was assumed based on teacher judgment and average standing on standard achievement tests.

LD Ss were selected from 24 classrooms in three schools for children with learning disabilities located in the greater New York metropolitan area. These children had been clinically diagnosed and classified as LD under the regulations of New York or New Jersey. Mean WISC-R IQ was 100.69 (SD = 11.75) for the younger LD group and 100.72 (SD = 9.78) for the older LD group. Current achievement data in academic areas were not available for all Ss, but most showed significant discrepancies between aptitude and achievement, according to teacher judgment. This was corroborated by review of available past achievement test scores. The children represented a broad range of socio-economic classes as judged by parents' occupations.

Materials and Procedures

The two sets of materials used in this study were designed to investigate

rapid repeated naming (The Naming Task) and proficiency on addition, subtraction and multiplication basic fact problems (The Arithmetic Task). The Arithmetic Task was administered to all subjects prior to the Naming Task; the interval between administration of the two tasks ranged from 7 to 8 weeks.

<u>The Naming Task</u>. The Rapid Automatic Naming Task (RAN, Denckla & Rudel, 1976) was used to measure repeated naming speed. It consists of four charts, each measuring 21.59 cm. by 27.94 cm., and each containing representations of five different items which are repeated ten times in random sequence. The 50 stimuli of each chart are evenly spaced and arrayed in 5 rows with 10 stimuli per row. A chart contains either lower case letters (p, o, d, r, s), numbers (2, 6, 9, 4, 7), color squares (red, green, black, blue, yellow), or line drawings of common objects (comb, key, clokc, scissors, umbrella).

Each <u>S</u> received all four charts according to a previously determined counter-balanced order of presentation. One chart at a time was displayed by the examiner (<u>E</u>) who asked each <u>S</u> to label the items to insure familiarity of the stimulus names. After acsertaining that <u>Ss</u> were able to supply these names, <u>E</u> instructed <u>S</u> to name the things on the card as fast as possible without making mistakes. Performance was timed with a stopwatch, and time per chart was recorded on a protocol which was a facsimile of each chart.

<u>The Arithmetic Task</u>. This task was designed to measure the speed and accuracy of written responses to basic fact problems in addition, subtraction and multiplication. Three separate two-page tests, each covering one operation, were devised by randomly arraying 98 basic fact problems. Numerals were printed in bold "primary" type; all problems were presented in a vertical format, arrayed in seven rows, each containing seven items. Horizontal lines delineated one row, with space for answers, from the next.

All <u>Ss</u> received the addition and subtraction tests; only older <u>Ss</u> received the multiplication test. Order of presentation was counter-balanced. The tests were group administered by the classroom teacher, who timed them,

allowing three minutes for each. At the conclusion of the three-minute interval, students were instructed to turn their papers face down, and tests were collected before the next was distributed.

Results

The purpose of this study was to determine the extent of the relationship between performance on a measure of automatization (RAN) and proficiency in computation of basic number facts.

Comparative RAN Results

Number of seconds taken to name the 50 items of each RAN chart was recorded for each child; total naming time for all charts was computed and constituted the major dependent measure of the RAN test.

Table 1

Rapid Automatic Naming (RAN) Total Time in Seconds

Group	Younger Subjects	Older Subjects	Total Group
Learning Disabled			
Mean	207.43	160.47	183.95
SD	57.72	40.77	55.06
Nondisabled			
Mean	151.73	141.53	146.63
SD	38.47	32.96	36.04

Table 1 reports RAN performance scores for groups according to age level. Results of a 2 x 2 analysis of variance (group x age) revealed significant main effects for group ($\underline{F}$ (1, 236) = 43.88, $\underline{p} < .001$) and for age ($\underline{F}$ (1, 236) = 29.99, $\underline{p} < .001$). These findings indicate that overall, LD children were slower than nondisabled Ss, and that younger children were slower than older children. A significant interaction of group and age was also found ($\underline{F}$ (1, 236) = 9.74, $\underline{p} < .002$). Follow-up tests for simple effects revealed that there was no significant difference between the RAN performance of younger and older nondisabled Ss, but that the difference between younger and older LD Ss was significant ($\underline{F}$ (1, 236) = 35.01, $\underline{p} < .001$). Thus, the RAN performance of only LD Ss improved with increasing age.

Comparative Arithmetic Results

Two scores were derived from each arithmetic test: number attempted (of 98 problems) and number correct. The two scores are related in that number correct is constrained by number attempted. Therefore, a ratio score of number correct to number attempted was also computed. This ratio score was designated as a proficiency score. For each subject, addition and subtraction scores were combined in computing the proficiency score (Basic Facts A). For the older 60 subjects, an additional proficiency score was computed, combining addition, subtraction and multiplication (Basic Facts B). Although this additional dependent measure provides some redundant information, it is considered to reflect most adequately the overall basic fact computational performance of the older subjects of each group.

To compare the proficiency of LD and nondisabled children in computing basic number fact problems, a 2 x 2 (group x age) analysis of variance was

employed to analyse Basic Fact A scores. Main effects were significant for group ($\underline{F}$ (1, 236) = 33.73, $\underline{p} < .001$) and for age ($\underline{F}$ (1, 236) = 96.21, $\underline{p} < .001$). The nondisabled children were more proficient in addition and subtraction than were the LD children; older Ss were more proficient than younger Ss. The interaction of age and group was not significant, indicating that for both groups arithmetic proficiency improved with age. (See Table 2.)

Table 2

Means and Standard Deviations for Number Attempted and Number Correct out of 196 Addition and Subtraction Basic Fact Problems

Group	Number Attempted		Number Correct	
	Mean	SD	Mean	SD
Younger				
Learning disabled	67.91	38.24	62.65	39.42
Nondisabled	94.50	32.10	92.13	32.90
Older				
Learning disabled	114.90	37.61	111.30	38.07
Nondisabled	140.38	36.67	137.47	37.72

In addition to the total group comparison, the proficiency of the older LD and nondisabled Ss was compared using Basic Fact B scores. A $\underline{t}$ test for independent samples revealed that the groups differed significantly on this composite measure, too ($\underline{t}$ (118) = 6.01, $\underline{p} < .001$). The older nondisabled Ss were more proficient than the older LD Ss in computing basic fact problems (See Table 3).

Table 3

Means and Standard Deviations for Number Attempted and Number Correct out of 294 Addition/Subtraction/Multiplication Basic Fact Problems

Group	Number Attempted		Number Correct	
	Mean	SD	Mean	SD
Learning disabled				
(N = 60)	160.97	56.94	151.80	58.45
Nondisabled				
(N = 60)	217.30	51.78	213.03	52.97

Major Findings

The purpose of this study was to examine the extent of the relationship between RAN performance and basic fact computation performance. To investigate this relationship, Pearson product-moment correlation coefficients for Basic Facts A and total naming time were derived separately for the LD and nondisabled groups. Additionally, Pearson correlations between Basic Facts B and total naming time were computed for each group of older subjects. Results are reported in Table 4.

Table 4

Correlations of RAN Performance and Basic Number Fact Proficiency Computed by Pearson r

Group	Coefficients
Total	RAN/Basic Facts A
Learning Disabled	-.50*
Nondisabled	-.49*
Older	
Learning Disabled	-.34*
Nondisabled	-.57*

*Significant at the .001 level.

N.B. The negative sign which accompanies each correlation results from the inverse relationship of time elapsed to proficiency on each measure. Superior performance on RAN is noted by a low score (less time taken), whereas superior performance on the arithmetic task is noted by a high score (more problems solved). The negative signs reflect differences between the scoring systems, not the nature of the relationship.

The results of the correlational analyses demonstrated that, for the total LD group, RAN performance accounted for 25 percent of the variance in performance on Basic Facts A. For the total nondisabled group, RAN accounted for 24 percent of the variance in Basic Facts A. When Basic Facts B performance is considered, RAN accounts for 12 percent of the variance for the LD group and 33 percent of the variance for the nondisabled group. There were no significant differences in the values of the correlations between Basic Facts A and RAN for the total LD and nondisabled group (*z* obs. = .08, *p* = .94) or for Basic Facts B and RAN (*z* obs. = 1.57, *p* = .12). Thus, the relationship between performance on RAN and on arithmetic basic fact computation was significant for both LD and nondisabled children, and the extent of this relationship did not differ significantly between either of the two total groups or the two older groups.

Discussion

The results of this study demonstrated that a significant relationship exists between basic number fact proficiency and performance on the RAN task in both the LD and nondisabled groups studied. Within both groups, greater proficiency in simple computation was associated with greater speed on RAN, while less proficient computation was associated with slower RAN performance. The degree of association was substantial, indicating that some aspects of performance may be common to both tasks. Since correlations do not specify the nature of a relationship, it has yet to be determined whether poor basic fact proficiency may be, in part, attributable to weak automatization as reflected in slow RAN performance. The correlation values obtained support the usefulness of such further investigation.

In addition to the correlational results, it was also found that children at each age level performed less well than their nondisabled peers on the RAN task. This poorer RAN performance was anticipated, given the results of previous research (Blumenthal, 1977; Clarkson & Broverman, 1977; Denckla & Rudel, 1976; Drake & Schnall, 1966; Eakin & Douglas, 1971). A tenable interpretation of this finding is that the group differences in RAN reflect differences in the automatization dimension of cognitive style. It may be that LD children are "weak" automatizers in relation to their nondisabled peers.

Implicit in the construct of automization cognitive style is the notion that processing is speeded as extended practice reduces the attention required to perform routine components of tasks. The less proficient arithmetic performance of the LD children suggests that the thinking processes by which they derived correct answers were more circuitous and/or attention-demanding than those employed by their nondisabled peers. It has been proposed that LD children's difficulty in managing the "flow of attention" may result from "incomplete automaticity of certain subprocesses" (Farnham-Diggory & Gregg, 1975, p. 197). While careful examination of the specific subprocesses which may be involved has yet to be undertaken, results of the present study suggest that the tendency to be weak automatizers may be implicated in their poor arithmetic performance.

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